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Collegiate Internship
Kennedy Space Center

PORT II

Muniz, Beau

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Reviewed by:

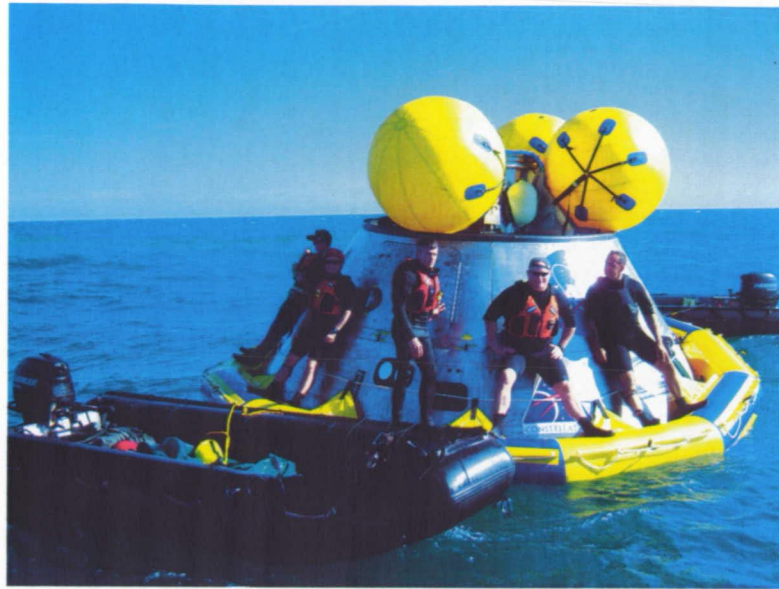
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Designing anything that goes into space is a very difficult and precise process. It takes a lot of steps and checks in a design before it is ready to survive the journey to space and then the harsh conditions of a low gravity vacuum. NASA has been building rockets and space vehicles for over 50 years, but the process of creating a launch vehicle has not veered from the proven design process. It starts with a concept, a general idea of “what” a component or vehicle will do. All the general ideas are thought up, but then it is followed by the “how”, and that is where prototyping comes in. The initial concept generally uses very little engineering just to make sure the concept is feasible. There are pictures and some diagrams, maybe even some rough dimensions, but not anything that is built, let alone any working parts. The prototyping phase can be anything as simple as a plastic model up to a working prototype that is near identical to the flight equipment or component. The Prototype Lab at Kennedy Space Center does everything from Acrylic models to tools used on flight equipment. There are a lot of machining capabilities with mills, presses, lathes, and even some electro-magnetic discharge machines and a water jet. For models and quick ABS mock ups, we have a rapid prototyping FDM machine that can do everything from rocket models for show to make workable joints that can either be used as parts or for quick prototyping of a part. All of these capabilities along with in house mechanical engineers and technicians allow for a variety of work to be done in the lab.

One unique project that the Prototype lab worked on was PORT I (Post-landing Orion Recovery Test). PORT is designed to test and develop the system and components needed to recover the Orion capsule once it splashes down in the ocean. These tests started with PORT I, a test to design a flotation collar that would be attached by recovery personnel and would meet the standards needed to be used on Orion. A mockup was created with a similar weight and center of gravity to the real Orion capsule. The Prototype Lab worked on the flotation devices, prototyping the design that will be used to float and stabilize the capsule which was the main purpose of the test. The capsule was designed and built by the Navy at the Naval Surface Warfare Center's Carderock division for the NASA team at Johnson Space Center and tested at Carderock, as well as in the ocean off of Cape Canaveral. PORT I was successful and showed that a flotation collar and support balloons could be used to stabilize the Orion capsule. The test did not utilize a pressure vessel with personnel inside, but rather relied on water tanks to simulate the capsule's flight weight and center of gravity.



PORT II is designated as a follow up to PORT I that will utilize a mock up pressure vessel that is spatially comparable to the final Orion capsule. The purpose of PORT II is to have all the equipment necessary to simulate an Orion capsule during astronaut egress in the ocean. In that respects the top and side hatch on the mock up must simulate the right weight, latching mechanism and momentum of Orion and the interior must spatially be the same as the real capsule. In doing that, a design must be made of these components that utilizes part of the Orion design and dummy parts to replace flight hardware, all while maintaining the right weight and center of gravity. This, to say the least, is a large project, one that has many contracts and components and challenges in maintaining certain qualities of Orion in a comparably cheap mock up. Due to budget restrictions, the existing PORT I capsule needs to be modified for PORT II. The job will need to be done in Pro-Engineer, the 3D modeling software decided on for the Constellation Program, in order to utilize Lockheed Martin's latest version of the Orion Capsule in creating the interior of the capsule for testing. The problem in doing that is that Carderock uses SolidWorks, another 3D modeling software and all of their models for the design are in that program. Thus the original design needs to be changed into a Pro-Engineer model that can be used for the rest of PORT.

Luckily enough, SolidWorks parts can be imported into Pro-Engineer, however there are many missing parts to the model. When parts are imported they come in as "blobs". What this means is they don't have any references to planes or any qualities that define a design; they are floating in space with no references and they do not have a density or material, and they aren't on KSC design standards. So without these assigned properties or parameters of a part, the floating blobs are almost useless beyond looking like the capsule. The importance of having properties and qualities such as materials and references is due to the importance of weight,

center of gravity, and the ability to redesign off of the model for PORT II. The objective of PORT II cannot be reached with the current SolidWorks model. But, as useless as the models are untouched, many can be converted over through a process, that if done correctly and with mapkeys (user created shortcuts that do repetitive tasks in Pro-Engineer) it can assign the necessary properties needed for PORT II. My job, along with other coops and interns, is to convert these parts and reassemble them in an organized and efficient manner. The parts aren't always convertible because some imported parts come with errors that make the imported geometry useless, so those parts must be remodeled. Our lab took possession of the mock up capsule temporarily after ocean testing in PORT I to clean up the rusted metal, but since we had it in possession it left us in a good position to convert and remodel the existing capsule. Since the conversion method is finicky and some design modifications might have been made after the SolidWorks model, having the actual capsule to reference off of makes the process much more valid and much easier.



The conversions had to be organized before anything was actually done. Since there were four people working on the project, an excel spreadsheet database of all the parts and assemblies was created so nothing would be done over by two people. This database was similar to a library checkout sheet, where all the parts were cataloged and could be checked out. Whenever an assembly of parts was taken to convert or model, it would be highlighted in whatever color was assigned to each person working on the project. Then, the database would be searched in order to find any repeating parts in that assembly. If a part in the highlighted assembly was also in another assembly that part would be highlighted that so it wouldn't be converted again or remodeled. There were a string of issues that needed to be solved in trying to develop how the

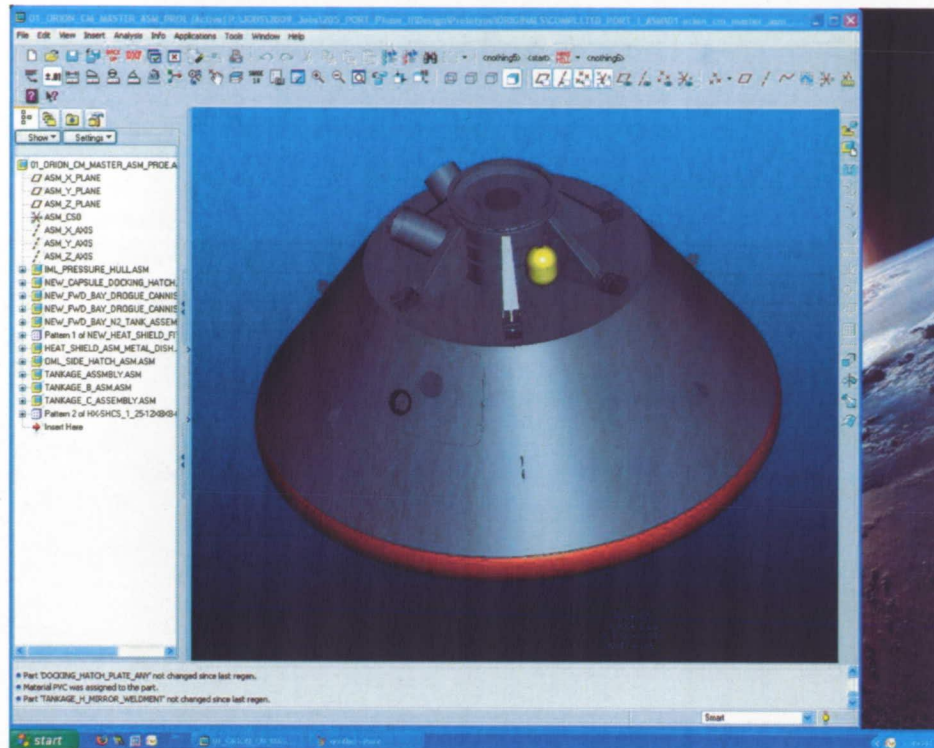
structure would be assembled and converted. We put the development of the final assembly off until the sub assemblies and parts were all converted because there wasn't a need to figure out the specifics until we got to that step in the process. The process for converting was established through informal meetings. The meetings were held to outline different issues of organization and standards. The organization and standards were covered in order to efficiently convert parts in a uniform manner so that the final product doesn't have naming differences, repeated parts, and inconsistencies. It was decided that a folder of the unconverted parts would be the source of the checked out parts. These parts would be converted in the lowest sub assemblies and then transferred over to a completed folder. From there, once all the conversions for the parts were finished, a new assembly would be made to organize the sub assemblies into the final capsule assembly.

Conversions require a unique set of Pro-Engineer skills. These skills aren't the most complex, but there is a lot of repetition required to convert a part. For the repetitive parts, there is a function within the program called mapkeys, which essentially executes a series of automated actions recorded by the user by hitting a few keys on the keyboard. Mapkeys can reduce conversion time from twenty minutes to one minute, which is a powerful tool in a large project such as PORT. If the conversions can't be used on a part, remodeling is needed. Modeling requires use of Pro-Engineer tools to create an identical part. This is a very common practice of Pro-Engineer and there are many different tools and functions that make it possible to model.

Assemblies are the next step after all parts are converted. New assemblies make the process easier, since even though parts are converted, they aren't constrained to other parts within the old assembly, rather they are spatially where they need to be, but have nothing holding them there. The problem with this is without constraints the assembly is invalid and thus unusable.

After getting a week into the project, a program called WindChill, a web based job organization tool that serves as a controlled library of parts and assemblies when used with Pro-Engineer, was used to access tools needed to do the project. Unfortunately, once access was gained on WindChill, it was discovered that the method of conversion was missing some parameters and relations that were needed to be compliant with WindChill standards. Some parts could be fixed easily, but nine out of ten parts needed to be redone...completely. It was the project's first major roadblock; and it was a really big one. It put the team back a week and slowed down the rest of the conversion process. Fortunately it came in the first quarter of the project and not in the final stages. The problem was frustrating, but it just showed an unfortunate part of engineering. There are always minor details that can invalidate the whole project. Although it was a delay in the job, it was an acceptable delay that hopefully kept another larger delay from happening.

The conversions of the PORT I model are an important part of PORT because it allows PORT II to begin with an apparatus for design. The Prototype Lab hoped to be the main vendor for the design and fabrication of the PORT II capsule, but due to insufficient funding, the project managers had no choice but to use in house Johnson Space Center shops so travel and replication costs could be cut. The PORT conversions created a useable platform for the design of the pressure vessel in a cheap and effective manner that will help PORT continue to provide feedback to the design of the Orion capsule.



This project has taught me a lot about Pro-Engineer and some processes I can expect if I ever work as a Mechanical Engineer on a job. I had learned Pro-Engineer the first few weeks of my internship, but the program is so massive that it takes a whole 3D software course to get a good knowledge base of it. I learned how to do conversions and started a tankage flotation device that was on the inside of the outer shell on the capsule. I learned about the usefulness of mapkeys in the program, which essentially do established processes by typing in combinations of a few letters on the keyboard. Another coop sat down with me for a couple of hours and taught me the ins and outs of it. Although I didn't get everything the first day, by the end of converting the parts a few weeks down the road, I had learned way more than I could have hoped for. The process took me a while since I was not acclimated to the program, but I still felt productive for the ability I had. This project, as well as my internship has given me a vast wealth of knowledge of Mechanical Engineering and NASA. It has been a wonderful experience that I will always remember and one that will greatly shape my future.